**Scientific Method Steps**

As more proof that there is no one way to "do" science, different sources describe the steps of the scientific method in different ways. Some list three steps, some four and some five. Fundamentally, however, they incorporate the same concepts and principles.

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| Scientific method flow chart­ |

­­For our purposes, we're going to say that there are five key steps in the method.

**Step 1: Make an observation**Almost all scientific inquiry begins with an observation that piques curiosity or raises a question. For example, when **Charles Darwin** (1809-1882) visited the Galapagos Islands (located in the Pacific Ocean, 950 kilometers west of Ecuador), he observed several species of finches, each uniquely adapted to a very specific habitat. In particular, the beaks of the finches were quite variable and seemed to play important roles in how the birds obtained food. These birds captivated Darwin. He wanted to understand the forces that allowed so many different varieties of finch to coexist successfully in such a small geographic area. His observations caused him to wonder, and his wonderment led him to ask a question that could be tested.

**­Step 2: Ask a question**The purpose of the question is to narrow the focus of the inquiry, to identify the problem in specific terms. The question Darwin might have asked after seeing so many different finches was something like this: What caused the diversification of finches on the Galapagos Islands?

Here are some other scientific questions:

* What causes the roots of a plant to grow downward and the stem to grow upward?
* What brand of mouthwash kills the most germs?
* Which car body shape reduces air resistance most effectively?
* What causes coral bleaching?
* Does green tea reduce the effects of oxidation?
* What type of building material absorbs the most sound?

Coming up with scientific questions isn't difficult and doesn't require training as a scientist. If you've ever been curious about something, if you've ever wanted to know what caused something to happen, then you've probably already asked a question that could launch a scientific investigation.

**Step 3: Formulate a hypothesis**The great thing about a question is that it yearns for an answer, and the next step in the scientific method is to suggest a possible answer in the form of a **hypothesis**. A hypothesis is often defined as an educated guess because it is almost always informed by what you already know about a topic. For example, if you wanted to study the air-resistance problem stated above, you might already have an intuitive sense that a car shaped like a bird would reduce air resistance more effectively than a car shaped like a box. You could use that intuition to help formulate your hypothesis.

Generally, a hypothesis is stated as an "if … then" statement. In making such a statement, scientists engage in **deductive reasoning**, which is the opposite of inductive reasoning. Deduction requires movement in logic from the general to the specific. Here's an example: If a car's body profile is related to the amount of air resistance it produces (general statement), then a car designed like the body of a bird will be more aerodynamic and reduce air resistance more than a car designed like a box (specific statement).

Notice that there are two important qualities about a hypothesis expressed as an "if … then" statement. First, it is testable; an experiment could be set up to test the validity of the statement. Second, it is falsifiable; an experiment could be devised that might reveal that such an idea is not true. If these two qualities are not met, then the question being asked cannot be addressed using the scientific method.

**Step 4: Conduct an experiment**  
Many people think of an experiment as something that takes place in a lab. While this can be true, experiments don't have to involve laboratory workbenches, Bunsen burners or test tubes. They do, however, have to be set up to test a specific hypothesis and they must be controlled. Controlling an experiment means controlling all of the variables so that only a single variable is studied. The **independent variable** is the one that's controlled and manipulated by the experimenter, whereas the **dependent variable** is not. As the independent variable is manipulated, the dependent variable is measured for variation. In our [car](http://auto.howstuffworks.com/automobile.htm) example, the independent variable is the shape of the car's body. The dependent variable -- what we measure as the effect of the car's profile -- could be speed, gas mileage or a direct measure of the amount of air pressure exerted on the car.

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| scientist **If this scientist is doing his job right, he's observing a control group and an experimental group.** |

Controlling an experiment also means setting it up so it has a **control group** and an **experimental group**. The control group allows the experimenter to compare his test results against a baseline measurement so he can feel confident that those results are not due to chance. For example, in the Pasteur experiment described earlier, what would have happened if Pasteur used only a curved-neck flask? Would he have known for sure that the lack of bacteria growth in the flask was because of its design? No, he needed to be able to compare the results of his experimental group against a control group. Pasteur's control was the flask with the straight neck.

Now consider our air-resistance example. If we wanted to run this experiment, we would need at least two cars -- one with a streamlined, birdlike shape and another shaped like a box. The former would be the experimental group, the latter the control. All other variables -- the weight of the cars, the [tires](http://auto.howstuffworks.com/tire.htm), even the paint on the cars -- should be identical. Even the track and the conditions on the track should be controlled as much as possible.

**Step 5: Analyze data and draw a conclusion**During an experiment, scientists collect both quantitative and qualitative data. Buried in that information, hopefully, is evidence to support or reject the hypothesis. The amount of analysis required to come to a satisfactory conclusion can vary tremendously. Because Pasteur's experiment relied on qualitative observations about the appearance of the broth, his analysis was fairly straightforward. Sometimes, sophisticated statistical tools have to be used to analyze data. Either way, the ultimate goal is to prove or disprove the hypothesis and, in doing so, answer the original question.